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A Criticism of Willett's Operation for Talipes Calcaneus.

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REPRINTED FROM

The New York Medical Journal

for August 23, 1890.

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A CRITICISM OF WILLETT'S OPERATION FOR TALIPES CALCANEUS.*

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The object of Mr. Willett's † resection is to shorten the tendo Achillis and other fibrous structures at the back of the leg, the abnormal length of which produces talipes calcaneus with its characteristic elevation of the toe and depression and enlargement of the heel.

We are apt to speak of the *deformities* which are seen in orthopædic practice, but it would be more accurate in many cases to use the word disability instead of deformity. In talipes calcaneus, for instance, the deformity is not important. A large heel and a small anterior part of the foot do not make, in an ordinary case, a bad deformity. But the disability attending every case is very serious.

In the normal condition the action of the muscles en-

* Read before the Orthopædic Section of the New York Academy of Medicine, March 21, 1890.

† Remarks upon Resection of the Tendo Achillis in Paralytic Talipes Calcaneus. Alfred Willett, F. R. C. S. St. Bartholomew's Hospital Report, 1880, pp. 307–310. Four Cases of Talipes Calcaneus of Paralytic Origin treated by Excision of a Portion of the Tendo Achillis. Mr. Walsham. *British Medical Journal*, June 14, 1884, pp. 1147, 1148.

ables the anterior part of the foot to support the body, and the result is an equable gait, the weight at each step coming first on the heel, and then, as the body presses forward, being transferred to the toe. But when the muscles are paralyzed the patient halts and is seriously crippled. He has the stumping gait which goes with a peg-leg. He can throw no weight on the anterior part of the foot, which might as well be absent so far as its usefulness in walking is concerned. A similar disability was produced by the American aborigines, who amputated the anterior part of the foot (Lisfranc's operation) to prevent the escape of a captive without lessening his ability to labor.

Dr. Holmes, using the accompanying cut as an illustration (Fig. 1), analyzes the complex act of walking in these

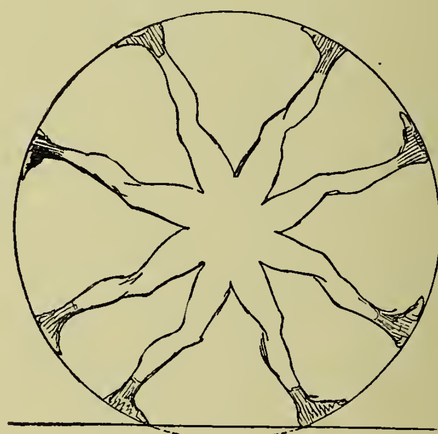

FIG. 1.

words: "Walking, then, is a perpetual falling with a perpetual self-recovery. Man is a *wheel* with two spokes (his legs) and two fragments of a tire (his feet). He *rolls* suc-

cessively on each of these fragments from the heel to the toe. If he had spokes enough he would go round and round as the boys do when they 'make a wheel' with their four limbs for its spokes. But, having only two available for ordinary locomotion, each of these has to be taken up as soon as it has been used and carried forward to be used again, and so on alternately with the pair." * Therefore, when a patient is disabled by paralytic talipes calcaneus, it may be said that some fragments are gone from the felloes of the human wheel.

The cause of the tendinous elongation in talipes calcaneus is obvious. At every step the foot is forcibly flexed on the leg without adequate muscular resistance at the heel, and the result is that the tendons become stretched and useless. In a normal limb the muscles at the back of the leg form a group of remarkable size and power, the principal function of which is to sustain the body when the foot is extended on the leg, and it is an interesting question whether the cicatricial tissue following a resection of the tendo Achillis is able to resist the weight which it is the function of this great muscular group to uphold. Extension of the foot on the leg while the limb is pendent or recumbent may be effected by the action of a few muscular fibers, but this function is of no importance compared with the power to hold the body on tip-toe, which can only be done by supreme muscular exertion.

In order to demonstrate clearly the severity of the strain which falls on the muscles of the calf and the tendo Achillis, I have made the machine shown in Figs. 2 and 3, in which wooden sticks represent the leg and the foot and a spring balance the tendo Achillis. The weight of the body

* The Human Wheel; its Spokes and Felloes. By Oliver Wendell Holmes. *The Atlantic Monthly*, May, 1863, pp. 567–580. Cut used by permission of the publishers.

is represented by a bag of shot weighing four pounds. The machine can be balanced in an upright position for an in-

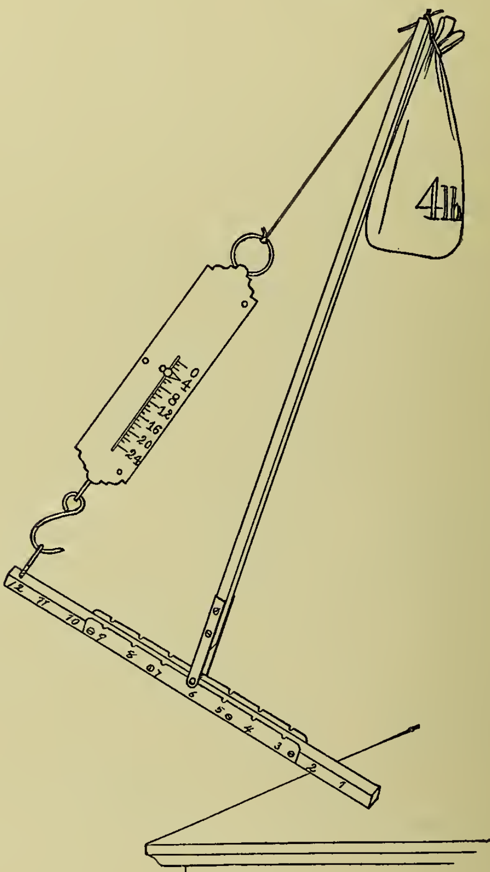

FIG. 2.

definite time by a light touch of the hand, and the joint representing the ankle is adjustable at any point between

the heel and the toe. On trial of the machine the spring balance is seen to vary in its registry when the joint representing the ankle is moved to a new point between the heel and the toe. When it is near the toe the balance registers a small fraction of a pound, and when it is at a point near the heel the balance indicates twenty or twenty-four pounds, the limit of the scale.

In Fig. 2 the ankle is half way between the heel and toe, and the balance registers four pounds, showing that if the ankle in the human foot were midway between the heel and toe the strain on the heel-cord would equal the weight of the body. In Fig. 3 the machine is so adjusted that it measures three inches from the ankle to the heel and nine inches from the ankle to the toe, a proportion which approximates nature. It is now seen that the balance registers twelve pounds, or three times the weight of the bag of shot which represents the body. It is thus demonstrated that if a boy weighs one hundred pounds the strain on his tendo Achillis when he is balancing on tip-toe approximates three hundred pounds.

It is noteworthy that the strain decreases as the vertical line through the heel approaches the vertical drawn through the toe and the center of gravity and disappears when these lines coincide, as they do perhaps in the extreme poise of the ballet-dancer. But in the ordinary movements and in what is attempted by an operation it is impracticable to try to reduce the strain on the tendo Achillis by exaggerated extension of the foot on the leg.

It is also noteworthy here that, if the gastrocnemius and soleus are paralyzed, it is impossible for the smaller muscles (the flexor longus pollicis, flexor longus digitorum, tibialis posticus, and the first and second peronei) to sustain unaided the weight of the body, not only from their small size, but also because they act at a peculiar disadvan-

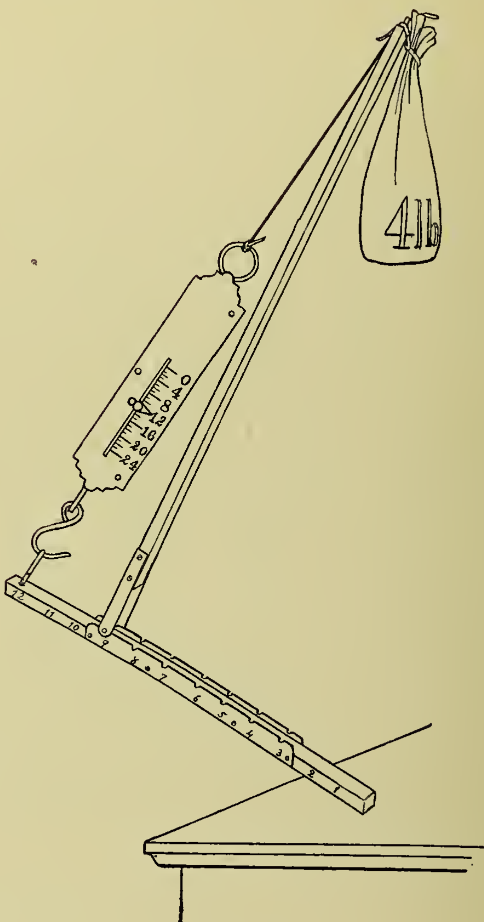

Fig. 3.

tage. The tendons of these muscles pass behind the malleoli to be inserted on the plantar surface of the foot,

and their ability to sustain the weight of the body is to be estimated as though they were in fact inserted at the posterior borders of the malleoli. This insertion is evidently much nearer the point of motion at the ankle than the posterior extremity of the os calcis, as may be seen in Fig. 4, from Marshall's *Physiology*, although the space is doubtless exaggerated in this cut.

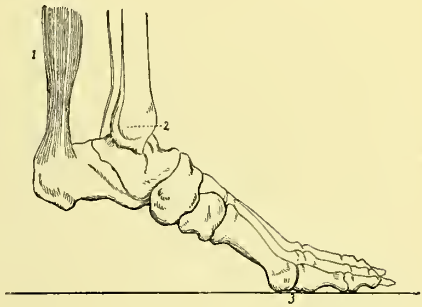

Fig. 4.*

The smaller muscles above mentioned, acting thus at a still greater mechanical disadvantage than the soleus and gastrocnemius, are more certain than they to be violently stretched when the weight of the body falls on the toe in the absence of adequate muscular contraction at the heel. The muscles in question are therefore very properly left out of our calculations.

That the tension falling on the heel cord greatly exceeds the corporal weight is thus seen to be a matter of physical demonstration. It is also found to be in accord with the formulæ of mechanics. It has long been recognized that the foot is a lever of the second order, as is shown in Fig. 4, the weight (2) being between the power (1) and the fulcrum (3).

Fig. 5 also shows a lever of the second order, the forces in equilibrium about the fulcrum C being the up-

* *Outlines of Physiology.* By John Marshall. American Edition, 1868, p. 163, Fig. 49. Cut used by permission of the publisher.

ward tension of the heel cord at A, represented by T, and the downward pressure of the tibia DB at B, represented by R. The moments being equal, $T \times AC = R \times BC$. As R is the resultant of the tension of the heel cord and the resistance of the ground at C, which is equal to the weight of the body, represented by W, $R = T + W$. Therefore $T \times AC = (T + W) BC$, or $T \times AC = T \times BC + W \times BC$, or $T \times AC - T \times BC = W \times BC$. But $AC - BC = AB$. Therefore $T \times AB = W \times BC$, or $T = \frac{W \times BC}{AB}$. If, now, the weight of the body is one hundred and fifty pounds and the distance from the ankle to the toe, BC, is six inches, and the distance from the ankle to the heel, AB, is three inches (a fair statement of the proportion, which is probably greater than two to one and less than three to one), the tension on the heel cord is $\frac{150 \times 6}{3}$, or $\frac{900}{3}$, or three hundred pounds.

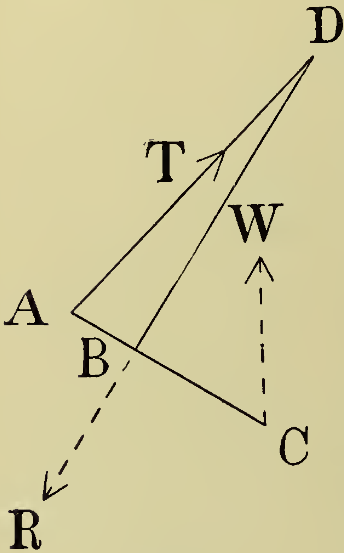

FIG. 5.

In this demonstration accuracy would require the forces to be considered in their perpendicular distance from the fulcrum, but practically the same result may be reached by the use of cosines, as in a valuable paper by Dr. William E. Wirt (*Medical Record*, June 28, 1890, p. 725). It is also

to be borne in mind that the tension is even greater than is represented above, because in some of the more violent movements of the body the strain is the sum of weight plus momentum.

It thus becomes difficult to believe that the cicatricial tissue formed in the tendo Achillis after resection will be able to endure the test of use. It is not likely that the cicatrix is ever broken, because patients habitually guard such a point from undue violence; but there is certainly nothing to prevent the tendon from again becoming elongated. It was lengthened, in the first place, by the weight of the body repeatedly falling on the toe in the absence of adequate contraction in the muscles of the calf. Muscular power is still absent, and the tendon, exposed to the same strain, will again become elongated in the cicatrix or in the fibrous tissue above or below.

I do not remember having read any earlier exposition of the mechanical disadvantage which falls to the lot of the tendo Achillis and the muscles of the calf.* It is not probable that this important point has been entirely overlooked. But the question of prior recognition and appreciation of the adverse lever at the ankle joint is less important than to again call attention to a simple and not very expensive method of mitigating, by mechanical means, the disability which accompanies talipes calcaneus.

The brace in question supplies the place of the anterior part of the foot. It does in a simpler and perhaps more effective manner what has been done before by other forms of apparatus. Its object is to prevent the foot from being flexed on the leg when the weight of the body falls on the toe. A growing child thus affected should wear this simple apparatus, not only because the gait is thus immediately im-

* *Vide* report of the January meeting of the Orthopædic Section, *New York Medical Journal*, March 1, 1890, pp. 246–249.

proved, but also persistently through the period of growth, because enlargement of the heel is thus prevented, and in after life the gait, without the brace, is much better than it would have been if the tendons and muscles of the calf had been over-extended at every step during the time of growth.

The brace restores to the patient the ability to stand on tip-toe, and to use the anterior part of the foot to sustain the weight of the body in ordinary locomotion, as well as in the more active movements of the body. Fig. 6 is copied from an instantaneous photograph dated 1885 of a patient, at that time a young girl, whose unaffected leg measured two inches and seven eighths more in circumference than the affected one. Without the brace she can not put the smallest fraction of her weight on the toe of the affected limb, but with the brace applied she balances herself on tip-toe with ease, as shown in the cut.

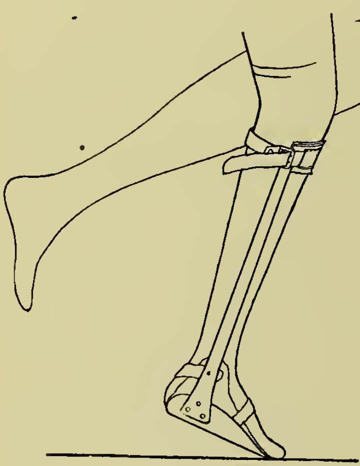

Fig. 6.

When I examined this patient recently, after an interval of several years, the (infantile) paralysis persisted, as was expected, but the deformity characteristic of talipes calcaneus was present in only a very moderate degree. She had worn the brace persistently with comfort and ad-

vantage. When she walks carefully, wearing the apparatus, her gait is free from the slightest defect. She sometimes lays it aside to please importunate but mistaken friends, but insists on wearing it when the duties of housekeeping are urgent, and will not appear out of doors without it.

This brace should be made without a joint at the ankle, differing in this respect from the one described in detail by me in 1885.* Experience has shown that the joint was useless, and the cause of frequent and expensive repairs. In some cases, also, the knee becomes slightly flexed, evidently because habitual flexion is necessary to enable the tibia to press against the padded strap at the upper part of the apparatus. It is therefore desirable to attach the upright near the posterior extremity of the foot-piece, and also to incline it backward at an angle (in some cases 10°), which may be determined for each case by repeated trials. The angle may be changed, for experiment, by a heavy blow delivered in an antero-posterior direction while the upright is suitably supported at each end.

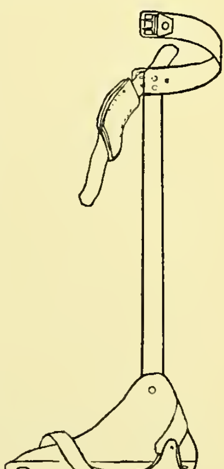

Fig. 7.

In other respects the brace, shown in its present condition in Fig. 7, is unchanged, and continues in use by a number of patients. It transfers the forces of weight and momentum, which in the normal foot are received at the ball of the toe, to the upper part of the anterior surface of the leg near the tubercle of the

* *Medical Record*, May 16, 1885, pp. 538, 539.

tibia, where a callus and an adventitious bursa are produced. Adults wear it constantly, as they would an artificial limb, with great increase of their ability to walk well and far.

In many cases the improvement in walking is partly due to an apparent increase in the length of the limb. The brace is easy to adjust, inexpensive, almost indestructible, and certain to add to the patient's comfort and ability. If necessary, webbing may be attached to prevent or lessen the valgous condition which often accompanics talipes calcaneus.

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